

THE NATURE OF STANDARD CONTROL IN CHILDREN'S MATCHING-TO-SAMPLE¹

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In Experiment I, six preschool-aged children were given matching-to-sample training with two figures in which they were required to choose one of two comparison stimuli that was identical in shape to the standard stimulus. Following this training, they were given intermittent test trials in which a novel stimulus figure was substituted for the previously correct comparison stimulus. Five of the six subjects consistently chose the substituted stimulus during test trials. Experiment II replicated the findings of Experiment I with three other preschool-aged children. Experiment II also provided controls for the possibility that the subjects of Experiment I were selecting the substituted stimulus because of its novelty. The investigators concluded that eight of the nine subjects were exhibiting the type of control described by Berryman, Cumming, Cohen, and Johnson (1965) as S-delta responding.

Key words: stimulus control, matching to sample, key press, children

In a study of control by spoken words over visual stimulus selection, L. Dixon (1977) trained eight retarded adolescents to select one of two visual stimuli (S+ *versus* S-) in response to a spoken word (a trained word). When a novel spoken word was introduced intermittently, all subjects consistently selected the previous S- in response to the untrained spoken word while continuing to select the previous S+ in response to the trained word. Dixon concluded that in choosing the previous S- on trials presenting the novel spoken word, the subjects were exhibiting a kind of responding-away-from the previous S+. This behavior suggested a complex type of relational control between the spoken word and choice stimuli for human subjects. It also led the present investigators to speculate that there may also be similar complex forms of relational control for humans in visual matching problems.

Berryman, Cumming, Cohen, and Johnson (1965) trained six White Carneaux pigeons to

select nonmatching comparison hues, as opposed to matching hues. A stimulus arrangement of three keys was mounted horizontally on a wall of their response chamber. At the start of a trial, the center key was illuminated with either a red, green, or blue hue. A response on this center key resulted in presentation of comparison stimuli on either side of the standard stimulus, which remained illuminated. One of the comparison keys was always illuminated with the same hue as the center key (a matching hue) and the other was always illuminated with a different hue; the latter was the correct choice. Berryman *et al.* suggested two alternate rules which might describe their subjects' behavior during this training. Under what they called the S^D rule, the hue of the center key would act as a cue for which of the two comparison hues to select. For example, if the sample stimulus is red, select green or blue. Under the S-delta rule, the hue of the center key would act as a cue for which comparison key not to select (if the sample is red, do not select red). After 20 sessions of training, a yellow hue was substituted whenever a blue hue had previously appeared. Berryman *et al.* suggested that the rule that best described the behavior of their subjects would be revealed by the subjects' performance on trials in which either red or green were the standard and matching comparison stimuli and yellow the nonmatching compari-

¹This work was supported by NICHD Grants HD 00870-14, HD 11194, and HD 07066, to the Kansas Center for Mental Retardation and Human Development, University of Kansas. The authors wish to thank Joseph E. Spradlin for his comments and suggestions for the research design and manuscript preparation. Reprints may be obtained from Michael H. Dixon, Parsons Research Center, Parsons State Hospital, Parsons, Kansas 67357.

son hue. The S^D rule would predict low percentages of correct responding on such trials, similar to the first day of training with red, green, and blue. The S-delta rule would predict higher percentages of correct responding, e.g., no change from the later sessions of training.

The results indicated that the behavior could best be described by the S^D rule. The pigeons' performances on trials for which the yellow hue was the nonmatching comparison stimulus were also identical to their performances during their first day of training. The hue of the standard key apparently did not act as a cue for which comparison hue not to select. These findings seem consistent with other investigations of matching-to-sample with pigeons (Cumming and Berryman, 1961; Farthing and Opuda, 1974; Urcuioli and Nevin, 1975). The combined results of all of these investigations strongly suggest that in matching-to-sample, the standard stimuli function to instruct the subject as to the correct comparison stimulus but do not function to instruct the subject as to the incorrect comparison stimulus.

Previous research by the present investigators required matching-to-sample behavior as a prerequisite skill for further experimentation with retarded subjects. During an occasional equipment failure in presenting the matching-to-sample stimuli, the correct comparison stimulus would fail to illuminate. On these trials, the subjects were presented with the standard stimulus, the incorrect comparison stimulus and a blank key. When this occurred, the subjects were observed to respond to the blank key. This suggested that the subjects might be choosing away from an incorrect comparison stimulus for the specific standard. In other words, the standard could be simultaneously functioning to instruct subjects as to which comparison stimulus to select (the S^D rule described by Berryman *et al.*) and as to which comparison stimulus not to select (the S-delta rule). The present investigation sought to determine how these rules applied to the behavior of young humans.

EXPERIMENT I

Subjects

Six normal preschool-aged children, ranging in age from 4 yr, four months to 5 yr, four

months with a mean age of 4 yr, 10 months, were bussed to the experimental setting daily from a day-care home and private residences.

Apparatus and Experimental Setting

The experimental apparatus was located in two adjacent rooms. One room contained a display panel mounted on a wall, a chair for the subject, an observation window, a doorbell, and a door buzzer. The display consisted of three 33-mm diameter circular display windows mounted in a small plastic panel. The standard window was centered 8 cm above the two comparison windows, which were arranged horizontally. Each of the three windows was equipped for rear projection with a series 0010 IEE projector. The two lower windows were also equipped with capacitance sensing switches, which could detect a touching response by a human subject. The doorbell and buzzer were mounted high on the walls of the subject's room so that they were out of reach. The adjacent room contained BRS solid-state programming equipment.

Procedure

A trial began with the three rear projectors illuminating the three windows simultaneously with the standard and two comparison stimuli. These were light figures on a dark (unilluminated) background. The stimuli were various shapes, which left 2 to 3 mm clearance from the sides of the 33-mm diameter windows. The stimuli disappeared when a subject touched a comparison stimulus window. A correct response produced chimes and an incorrect response produced a door-buzzer sound. Each intertrial interval was 3 sec in duration.

Subjects were taken individually into the experimental room and seated in the chair in front of the display windows. In the first session, the experimenter left the room momentarily to activate the display equipment and then returned. When the automated equipment presented the first trial, the experimenter said: "I want you to look up here," pointing to the standard window, "and then touch the thing just like it down here", while drawing a hand across the panel under the two comparison windows. After a subject made the first response, the experimenter explained that the doorbell rang because the child chose the right thing and that a buzzer would sound if the child chose the wrong thing. The instructions

for responding were repeated for the second trial. The experimenter then went into the apparatus room where he could not be observed by the subject.

Sessions were conducted once daily, five days per week. During training, a session consisted of 48 trials per day. During testing sessions, an additional eight trials were added, creating a total of 56 trials per day. Each session lasted approximately 5 min.

Figure 1 illustrates the nature of the training trials and test trials. As Figure 1 shows, Subjects 1, 2, and 3 were given either a star or an inverted mushroom as the standard and as comparison stimuli for the identity matching-to-sample training condition. The star and mushroom were presented an equal number of times on the standard window and an equal number of times on each comparison window for each of the respective standard stimuli.

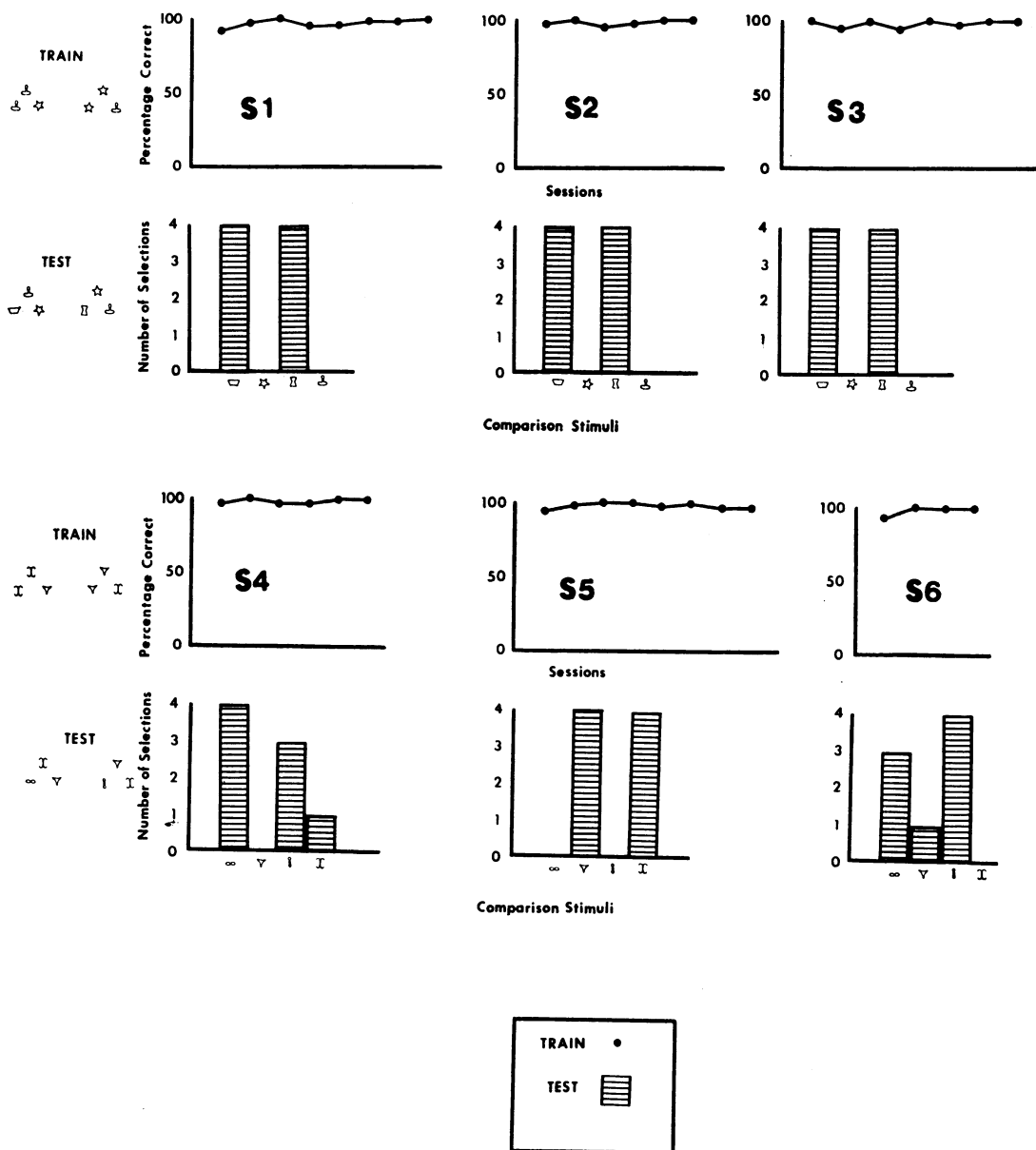


Fig. 1. The stimulus combinations for training appear at the left. The top two rows show the training and test results of Subjects 1, 2, and 3, e.g., Subject 1 received eight training sessions (Row 1) followed by one test session (Row 2). The bottom rows give the same information for Subjects 4, 5, and 6.

During four of the eight test trials in which the mushroom appeared on the standard window, the mushroom comparison stimulus was replaced by a trapezoid. During the other four test trials (when the star was presented on the standard window), the star comparison stimulus was replaced by an hourglass-shaped figure. These same procedures were applied to Subjects 4, 5, and 6, who were given training with X and triangle figures, which were subsequently replaced as the matching stimulus on test trials by an infinity sign and a chain-like figure, respectively.

Training. All subjects were given training under two consecutive contingency arrangements. Under the first arrangement, the doorbell or buzzer operated on each of the 48 trials until the subjects met a criterion of 100% correct responding for one session. Under the second arrangement, the bell or buzzer operated on an average of only one of every three trials. The intermittent use of the bell and buzzer was continued until subjects met a criterion of 100% correct responding for two consecutive sessions or for a total of eight sessions of the training conditions.

Testing condition. After receiving training, each subject was given one test session. This test session consisted of 48 trials of identity matching-to-sample plus eight test trials interspersed among the identity matching trials. A minimum of five identity matching-to-sample trials occurred between any two test trials. Neither the doorbell nor the buzzer operated on any of the test trials. The specific standard and comparison stimuli presented during the test trials are illustrated in Figure 1.

RESULTS

The training graph of Figure 1 shows the percentage of correct responding during training sessions for each subject. The bar graphs in Figure 1 show the number of times each comparison stimulus was chosen during the eight test trials of each subject's single test session. The ordinates of the bar graphs extend to four because each of the four figures shown on the abscissa appeared as a comparison stimulus four times during the eight test trials. Subjects 1, 2, and 3 chose the new or substituted stimulus on every test trial. Subjects 4 and 6 selected the substituted stimulus on seven of eight test trials. Only Subject 5

did not show this pattern of responding, choosing on every test trial the comparison stimulus that was previously incorrect for the specific standard.

DISCUSSION

The consistent selection of the substituted stimulus by five of the six subjects conforms to the S-delta rule described by Berryman *et al.* (1965). That is, for these subjects, the standard was a cue for which stimulus not to choose. The behavior of S-5, however, did not conform to this description. Although S-5 was responding systematically, his behavior was under the control of the previously incorrect, but familiar comparison stimulus. While this comparison stimulus was always incorrect for one standard, it was the correct choice for the other standard stimulus, *i.e.*, when it appeared as the standard stimulus during pretraining trials.

The possibility that stimulus familiarity controlled S-5's behavior raises the question as to whether stimulus novelty controlled the behavior of the other five subjects during test trials. Other investigators have suggested that young normal children prefer novel stimuli to familiar stimuli, as long as the novelty is not so dramatic or bizarre as to be frightening (Cantor and Cantor, 1964*a, b*; Green, 1964). This possibility led to another experiment similar to Experiment I but with insurance that the substituted stimuli would not be novel when encountered in test trials.

EXPERIMENT II

Subjects

Three preschool children 4 yr, three months, 4 yr, 10 months, and 4 yr, 11 months, with a mean age of 4 yr, eight months) who had not participated in Experiment I, were bussed daily to the experimental setting by the investigators.

Procedure

The procedures were generally the same as in Experiment I except that Experiment II subjects were given additional training to assure that the stimuli substituted for previously correct comparison stimuli would not be novel

during test sessions. Additional shapes were introduced as stimuli for Experiment II. Unlike Experiment I, training and testing was conducted twice with each subject during Experiment II. After initial training, a second set of stimuli was used to replicate findings within each subject. Figures 2 and 3 show the stimuli used with each subject for both instances of training and testing.

Training. Subjects were first given training

at identity matching-to-sample with one set of two stimuli (set 1). The sequence of contingency arrangements for training of set 1 stimuli was the same as in Experiment I. To avoid fatigue from the added pretraining with the stimuli to be substituted for comparison stimuli, the criterion for completing training with set 1 stimuli was reduced to one session at 100% correct responding under the intermittent bell and buzzer arrangement. Upon

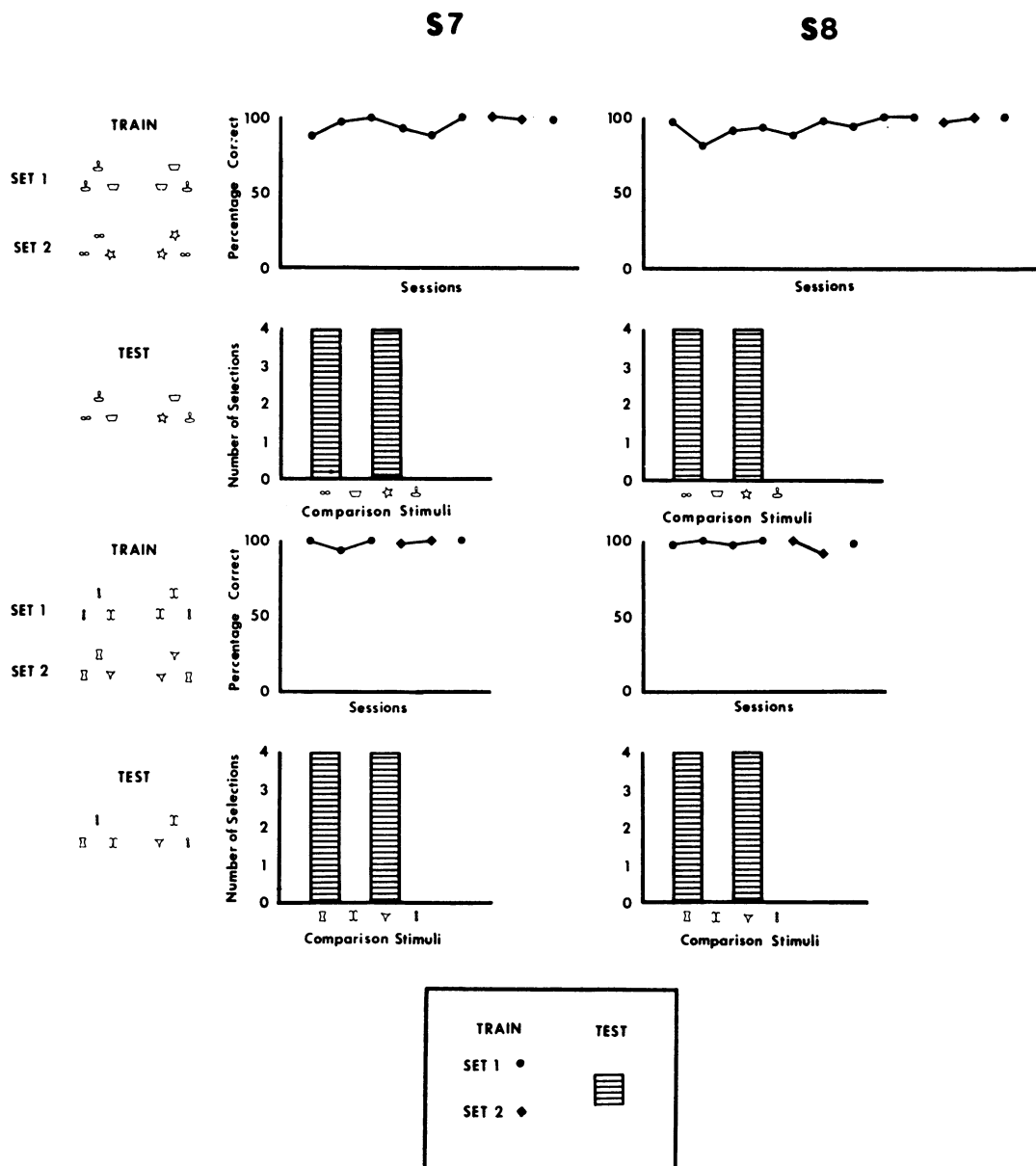


Fig. 2. Subject 7 (left column) and Subject 8 (right) were each given training on two sets of stimuli (shown at left) before substitutions were made (bars). Results were replicated within subjects.

S9

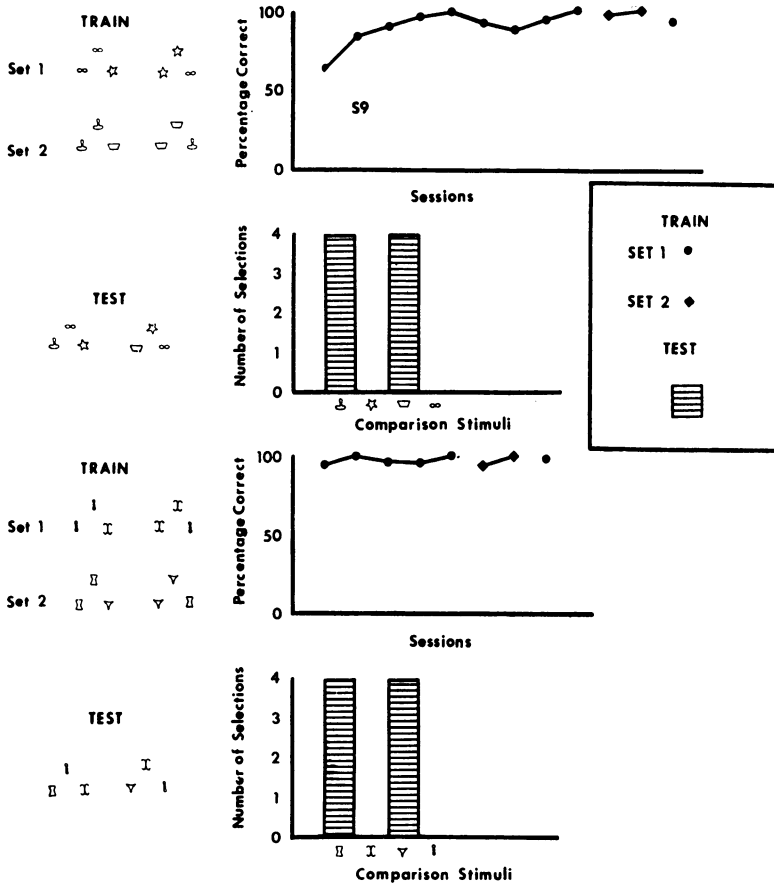


Fig. 3. Subject 9 was given a different sequence of the same stimuli used with Subjects 7 and 8, followed by the same sequence used for within-subject replication.

meeting this criterion, subjects were given two consecutive sessions of matching-to-sample with the stimuli that were to be substituted for comparison stimuli (set 2). Finally, they were given one more session of matching-to-sample with the set 1 stimuli.

Testing condition. As in Experiment I, the test session consisted of 48 trials of identity-matching-to-sample plus eight test trials interspersed among the identity matching trials. Test trials were interspersed at the same ratio as in Experiment I, and neither the doorbell nor the buzzer operated on test trials. S-9 was given a different combination of the same stimuli used with S-7 and S-8. When the test session was completed, Subjects 7, 8, and 9 were given training with yet another set of

stimuli, and all procedures including testing were replicated.

RESULTS

The bar graphs in Figures 2 and 3 show the number of times each comparison stimulus was chosen by each subject during each test session. As these graphs indicate, the subjects chose the substituted comparison stimulus rather than the comparison stimulus that was previously incorrect for the specific standard on every test trial on both instances of testing.

GENERAL DISCUSSION

The present investigation suggests that, in the kind of matching-to-sample exposure given

here, there are at least two types of control by the standard stimulus operating simultaneously, *i.e.*, the standard acts as a cue for which comparison stimulus to select and as a cue for which not to select. The existence of SP control is suggested by the results of Experiment II, where a second set of stimuli was presented for two sessions and accuracy of identity matching-to-sample was maintained. S-delta control is seen in both experiments, since eight of nine subjects chose a new non-matching stimulus, rather than the previously incorrect comparison stimulus. The fact that Subjects 7, 8, and 9 chose the substituted comparison stimuli after two sessions of matching-to-sample with those stimuli strongly indicates that novelty was not the variable controlling the subjects' selection of these stimuli in Experiment I.

Perceptual properties can be a particular problem in studies involving human subjects because the experimenter seldom has much control over the previous experiences of the experimental subjects. It is for this reason that the subjects of these experiments were assigned to so many different stimulus combinations (five in all). It is highly unlikely that eight of nine subjects would respond to that many arbitrary combinations on the basis of perceptual properties, and in such a way as also to select the comparison stimulus that was substituted for the previously correct comparison stimulus.

While the behavior of the present subjects follows the S-delta rule described by Berryman *et al.* (1965), the results differ from those obtained by Berryman *et al.* with pigeon subjects. That is, the standard stimulus apparently did not act as a cue for which stimulus not to select for the pigeons. The numerous differences between the present study and Berryman *et al.* make it difficult to explain the different results. It seems unlikely that the different results are due to correct responses being the "same" in the present study and "different" in Berryman *et al.* Such a conclusion would require the supposition that given the same general training paradigm, pigeons might acquire matching differently than they acquire oddity. Since neither matching nor oddity beyond specific standard-comparison-stimulus combinations has been demonstrated in pigeons given this kind of training (Cumming and Berryman, 1961; Berryman *et*

al., 1965), this supposition seems particularly weak.

A more likely explanation of differences is the age and experience of human subjects in the present study. By the age of 4 or 5 yr, a normal child will have encountered hundreds of same-different problems across numerous conditions. Exposure to educational television alone would provide many opportunities to acquire same-different concepts. The present subjects readily demonstrated matching-to-sample with very limited verbal instruction, and Subjects 7, 8, and 9 were given no instructions beyond the initial session. The high level of occurrence of matching-to-sample with novel or untrained stimuli in the latter portion of Experiment II suggests a matching-to-sample repertoire not demonstrated by the pigeon subjects. Premack (1976) demonstrated matching behavior in chimpanzees, and suggested that pigeons may fail at matching because of the limited number of training problems presented in the typical pigeon matching investigation.

The present investigation showed that in children's matching-to-sample, the standard can act as both a cue for which stimulus to select and which not to select. At present, little is known about the relationships between these two types of control or their roles in other matching behaviors. It is quite clear, however, that these two types of control can exist simultaneously and that both have the potential to influence the outcome of studies based on the initial establishment of matching-to-sample behavior.

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Received 19 December 1977.

(Final acceptance 10 April 1978.)